Industrial Equipment Inventory Data

In order to estimate the emissions benefit and costs of the off-road equipment rule, ARB staff must estimate the total population of affected equipment, its ages and characteristics, and how much it is used. ARB staff plan to use the ARB OFFROAD model as the primary tool to estimate off-road equipment population and emissions. However, we will update the model's assumptions where appropriate to more accurately reflect the fleet affected by the off-road equipment rule. ARB staff have evaluated other sources of off-road equipment inventory data including the following:

- United States Environmental Protection Agency (USEPA) NONROAD model – the USEPA's model of population and emissions from off-road equipment.
- 2005 ARB off-road equipment survey –The 2005 off-road equipment survey was conducted by ARB staff and included off-road equipment owned by both public and private entities.

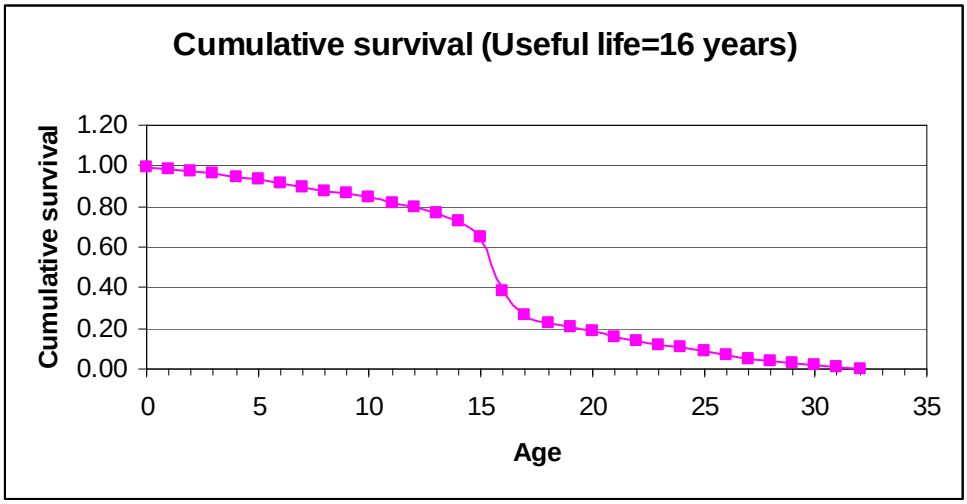
This discussion paper describes the equipment use, lifetime and population assumptions in the OFFROAD model for industrial equipment and compares them to comparable data from EPA NONROAD, and the 2005 off-road equipment survey. ARB staff have prepared similar discussion papers for construction/mining equipment and airport ground support equipment. We would like to solicit any additional data or comments regarding the values presented in this paper.

Equipment Use and Lifetime

Understanding how equipment naturally ages and is replaced will be important for predicting the costs and benefits of the off-road rule. One way to comply with the rule will be to turn equipment over to cleaner equipment, so understanding the natural turnover that would occur in the absence of the rule will be critical.

ARB's OFFROAD model and USEPA's NONROAD model assume that equipment enters the fleet, ages and is eventually scrapped. As equipment of a certain model year ages, each year some fraction of it is scrapped and some fraction of it survives. The cumulative survival at age x, S(x), is the fraction of equipment that survives to age x. By plotting survival versus age, the turnover of equipment can be represented by a survival curve. In the OFFROAD and NONROAD models, the survival curve is assumed to have a normal distribution of cumulative scrappage versus age. An example survival curve from the OFFROAD model is shown below in Figure I-1:

Figure I-1 – OFFROAD Model Cumulative Survival for Equipment of Useful Life 16 years



Eventually, all equipment of a certain model year will have been scrapped. When this occurs, cumulative survival equals 0. The survival curve for any given equipment type can be represented by one number, the useful life. The useful life, akin to a half-life, is the age at which the survival curve shows a point of inflection and is equivalent to when half of the units of a certain model year will have been scrapped. At the age of twice the useful life, all equipment will have been scrapped. The useful life for the survival curve shown in Figure I-1 is 16 years.

Both ARB's OFFROAD model and USEPA's NONROAD model estimate useful life based on the following equation:

Useful life (years) = Engine life at rated horsepower (hrs) / (Load factor x Annual Use (hours/year))

NONROAD caps maximum useful life at 25 years. Thus, the maximum age of equipment in NONROAD is 50 years.

Both OFFROAD and NONROAD use engine life at rated horsepower (hp) primarily from an analysis by Energy and Environmental Analysis, Inc. of on-highway engine life data, supplemented by interviews of engine manufacturers (EEA, September 2001). However, EPA did a recent review of the EEA work that resulted in USEPA using longer engine lives at rated hp than are used in the OFFROAD model (USEPA, April 2004). For example, NONROAD now assumes that diesel engines over 300 hp last 7000 hours at full load versus OFFROAD's 6,000 hours.

Load factor indicates the average proportion of rated horsepower used. OFFROAD uses load factors estimated by Power Systems Research (PSR) based on surveys of equipment owners regarding how they use their equipment (ARB, 1999). USEPA has done some recent work to refine these estimates, and NONROAD uses

load factors obtained from actual engine testing over several transient cycles (USEPA, April 2004).

OFFROAD uses estimates of annual use from the 1996 PSR database. NONROAD uses estimates of annual use from a 1998 database developed by PSR. Neither NONROAD or OFFROAD take into account changes in annual use as equipment ages. As shown in Table I-1 below, the annual use estimates are nearly identical, except that NONROAD's is slightly lower for forklifts.

Table I-1 includes the weighted average of annual use from ARB's 2005 off-road equipment survey for each industrial equipment type. For each equipment type, the reported annual use from each survey response was weighted by the number of equipment of a certain type for which annual use was reported. The annual use estimates from the survey are higher than in OFFROAD, except for forklifts. ARB staff will consider using the reported survey usage in the analyses of the off-road equipment rule and to update values in OFFROAD. Before making a final determination, however, we would like to solicit any additional data on annual use of diesel industrial equipment.

Table I-1 – OFFROAD vs. NONROAD Annual Use (hrs/yr) for Industrial Equipment[1]

Equipment Type	ARB OFFROAD Annual Use (hrs/yr)	USEPA NON-ROAD Annual Use (hrs/yr)	% difference = (NON-ROAD-OFFROAD) / OFFROAD	Average Annual Use from Off-road Equip-ment Survey (hrs/yr)	% difference = (Survey - OFFROAD) / OFFROAD	2005 Off-road Equip-ment Survey: # of Equip-ment with Annual Use Data
Aerial Lifts	384	384	0%	500	30%	25
Forklifts	1800	1700	-6%	535	-70%	414
Other General Industrial Equipment	878	878	0%	1425	62%	344
Other Material Handling Equipment	421	421	0%	1318	213%	107

Table I-2 below shows the useful lives for industrial equipment in the OFFROAD model and the average age when retired or sold reported in the ARB 2005 Off-road equipment survey. Useful lives range from 12 years to a maximum of 16 years in the OFFROAD model. NONROAD's lifetimes, by comparison, range from 2 to 25 years for industrial equipment. To determine the average age when retired for each equipment

type, the reported age when retired from each survey response was weighted by the number of equipment of a certain type for which age when retired was reported. The average age when retired from the survey ranged from 11 to 20 years. Because the survey reported average age when retired seem to match well with the OFFROAD useful lives (were within 30%), ARB staff proposes maintaining the useful lives in the OFFROAD model. We would, however, like to solicit any additional data on useful life of diesel industrial equipment.

Table I-2 – Useful Life Estimates for Industrial Equipment (years)

Industrial Equipment Types	ARB OFFROAD Useful Life	2005 Off-road Equipment Survey Average Age When Retired (years)	2005 Off-road Equipment Survey: # of Equipment with Age Retired Data
Aerial Lifts	16	20	17
Forklifts – 25-50 hp	12	11	384
Forklifts – 50-300 hp	12		
Forklifts – >300 hp	12		
Other General Industrial Equipment – 25-50 hp	16	11	262
Other General Industrial Equipment – 50-300 hp	16		
Other General Industrial Equipment – >300 hp	16		
Other Material Handling Equipment	16	15	82

Tier Distribution

Table I-3 and Figure I-2 show the distribution of industrial equipment among the various emission standard tiers as modeled in ARB's OFFROAD model for the year 2005. The fleet in 2005 is split among Tier 0, 1, and 2 equipment, with the largest portion of the fleet being Tier 1. We would like to solicit input from fleet owners on whether this tier distribution appears reasonable and consistent with their fleets.

Table I-3: 2005 OFFROAD Equipment Population by Emission Standard Tier for Industrial Equipment

Tier	Model Years[1]	Age of Equipment in Tier in 2005 (years)[1]	OFFROAD Population	OFFROAD Percent
0	Up to 1999	>=6	4292	39%
1	1996-2005	0-9	5115	46%
2	2001+	0-4	1724	15%

[1] – The effective dates of each emission standard tier vary by maximum horsepower. The off-road compression ignition engine standards are in Title 13, California Code of Regulations, Section 2423.

Figure I-2: 2005 OFFROAD Percent Population in Each Emission Standard Tier for Industrial Equipment

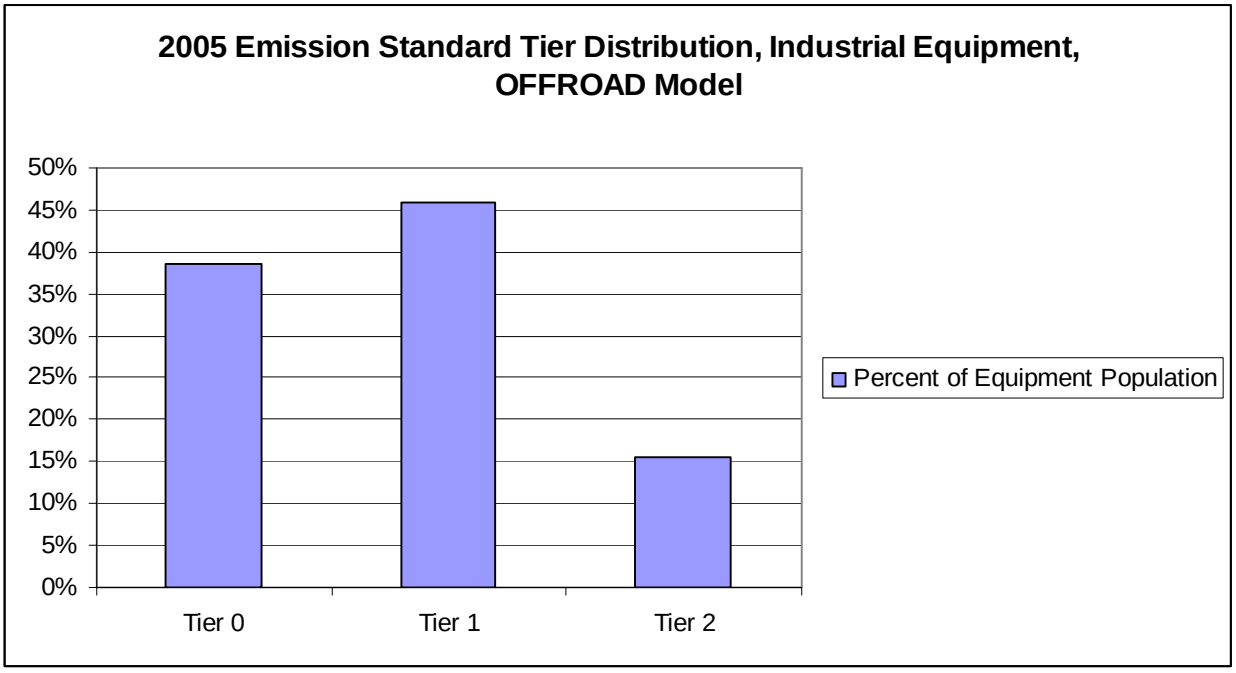


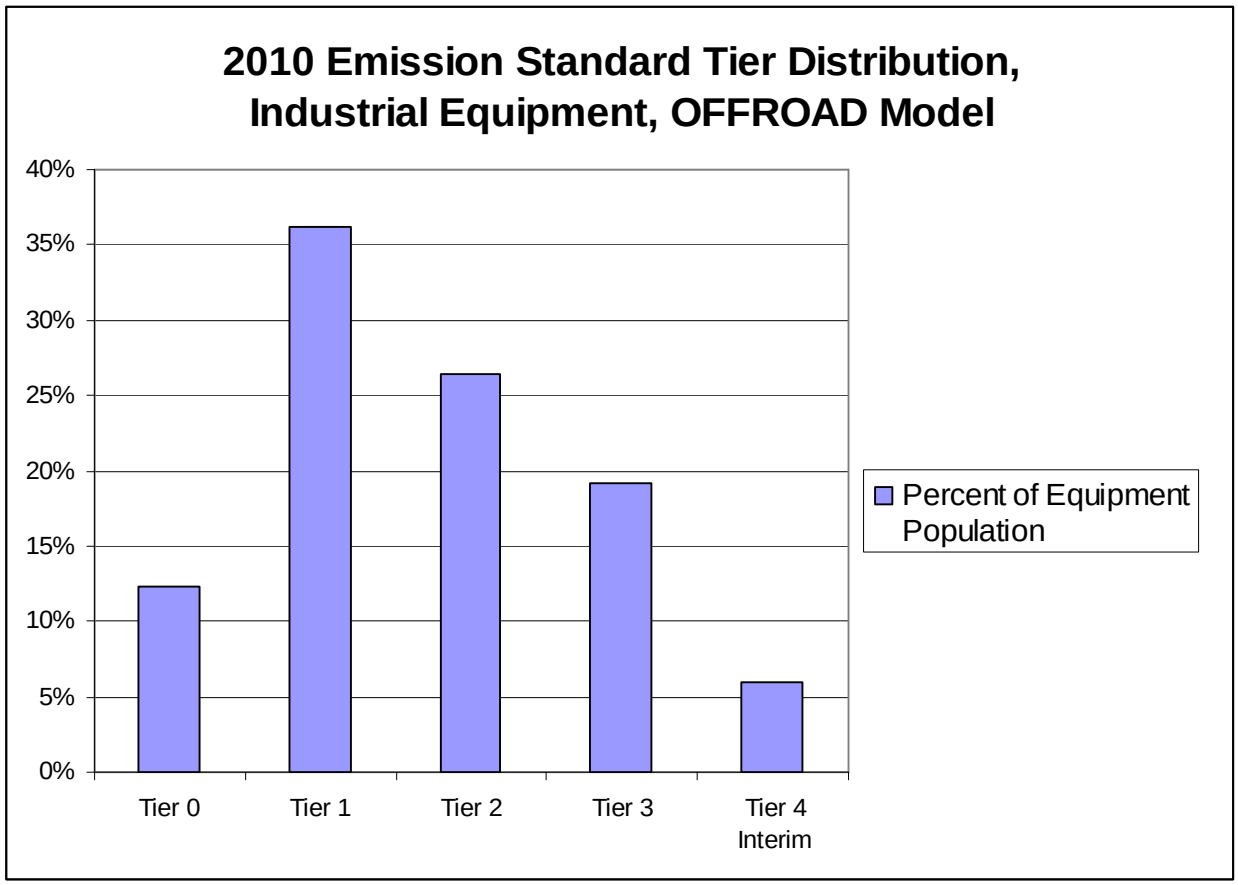
Table I-4 and Figure I-3 show the distribution of industrial equipment among the various emission standard tiers as projected in ARB's OFFROAD model for the year 2010. In 2010, the fleet is projected to be divided among Tier 0, 1, 2, 3, and interim 4 emission standard tiers. The largest portion of the fleet is projected to be Tier 1 in 2010, and Tier 0 is projected to make up just 12% of the industrial fleet.

Table I-4 - 2010 OFFROAD Population by Emission Standard Tier for Industrial Equipment

Tier	Model Years[1]	OFFROAD Population	OFFROAD Percent
0	Up to 1999	1421	12%
1	1996-2005	4169	36%
2	2001-2007	3046	26%
3	2006-2011	2215	19%
4i	2008+	685	6%

[1] – The effective dates of each emission standard tier vary by maximum horsepower. The off-road compression ignition engine standards are in Title 13, California Code of Regulations, Section 2423.

Figure I-3 - 2010 OFFROAD Percent Population by Emission Standard Tier for Industrial Equipment



Equipment Population

OFFROAD equipment populations for industrial forklifts are based on a Booz Allen-Hamilton 1992 report, and other industrial equipment populations are based on PSR's 1996 database (ARB, 1999). OFFROAD uses a base year of 2000 and then forecasts or backcasts populations from that year.

NONROAD equipment populations are based on estimates of sales of off-road equipment from PSR through the year 2000. NONROAD uses a base year of 2000 and then forecasts or backcasts equipment populations from that year. In NONROAD, the PSR sales data were combined with NONROAD estimates of load factor, activity, median life, scrappage, and growth, to obtain national equipment population estimates for each year (USEPA, December 2005). The national equipment populations were allocated to states based on the number of employees in manufacturing in each State.

Table I-5 shows equipment population by equipment type from the OFFROAD model for calendar year 2005 and the reported population of industrial equipment from the 2005 ARB off-road equipment survey. We did not receive enough survey data on industrial fleets to directly compare the total off-road equipment survey populations to the total OFFROAD populations. However, the survey data does suggest a higher fraction of other material handling equipment and other general industrial equipment than reflected in the OFFROAD model. NONROAD model populations for industrial equipment were very similar to OFFROAD for forklifts but were much higher for aerial lifts, other material handling equipment, and other general industrial equipment. ARB staff would like to solicit any additional data on industrial equipment populations.

Table I-5 – Estimates of 2005 California Population of Industrial Equipment by Equipment Type -- ARB OFFROAD model, USEPA NONROAD, and ARB 2005 Off-road Equipment Survey

	ARB OFFROAD	USEPA NONROAD	ARB 2005 Off-Road Equipment Survey
Aerial Lifts	1011	6189	36
Forklifts	5025	5648	473
Other Material Handling Equipment	175	732	127
Other General Industrial Equipment	1155	5232	381
Total Industrial	7366	17802	1017

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USEPA, April 2004. Median Life, Annual Activity, and Load Factor Values for Nonroad Engine Emissions Modeling, USEPA, EPA420-P-04-005, April 2004.

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